PRE-FEASIBILITY REPORT
FOR
ETHYLENE CRACKER, ITS ASSOCIATED FACILITIES, DOWNSTREAM UNITS AND EXPANSION OF BINA REFINERY (BR)

1. BACKGROUND

Bharat Oman Refineries Limited, a wholly owned subsidiary of Bharat Petroleum Corporation Limited (BPCL), is operating its Refinery located in the Central India at Bina, Dist. - Sagar, Madhya Pradesh, India. BORL Bina Refinery (BR) with crude processing capacity of 7.8 MMTPA currently is configured for producing auto fuels. In order to remain competitive and improve refinery profitability further, BR has identified Ethylene and Propylene based bulk commodity chemicals for its diversification to Petrochemicals.

2. INTRODUCTION

BR has embarked on Petrochemical Diversification Plan and intends to set up world scale Ethylene Cracker facilities & associated downstream petrochemical units at Bina along with expansion of its refinery capacity from present 7.8 MMTPA to about 12 MMTPA.

As diversification in the field of petrochemicals due to the profitability and value addition being higher in producing polymer products, the expansion of the refinery considers integrating the same with a Petrochemical Complex in order to expand their product portfolio while maximising the margins.

BR has carried out feasibility studies in the past through external consultants for setting up an Ethylene Cracker complex integrated with existing 7.8 MMTPA Bina Refinery for Petrochemical production. Under the present scope, Ethylene Cracker Complex of 1.2 MMTPA capacity based on captive feedstock like Naphtha, LPG, Kerosene, LGO, Hydrocracker UCO, DCU off-gas, etc. targeting production of High Density Polyethylene (HDPE), Linear Low Density Polyethylene (LLDPE), Polypropylene (PP), Butene-1, Benzene, Toluene, Mixed Xylene, etc.

Engineers India Ltd have been retained by BORL to provide services for the following:

(i) Licensor selection of licensed units like ECU, HDPE, LLDPE/HDPE, PP, Butene-1.
(ii) Preparation of Project DFR with +/- 20% accuracy, including development of Plot plan, project schedule and implementation etc.
(iii) EIA and RRA study

3. PFR OBJECTIVE

The broad objective of the PFR study is listed below.

I. Validation and finalization of in house developed Configuration study for Feed / Product optimization & adequacy checks for Refinery Process Units utilising Ethylene Cracker Complex LP Model integrated with BR.
II. Carry out Detailed Feasibility Study for setting up of
   a) Ethylene Cracker & Associated units / facilities for production of Petrochemicals building blocks. (Ethylene, Propylene, etc.)
   b) Downstream units / facilities for production of Petrochemicals like HDPE, LLDPE, PP, etc.
III. On completion of Configuration Study, “Request for Proposal” (RFP) for licensor scope of supply and services including supply of Technology know

how & BDEP to be prepared. Further, to carry out Licensor Selection and provide recommendation to BR.

IV. To carry out Detailed Feasibility, prepare Plot Plan as per OISD/Statutory guidelines, Over Dimensional Consignment (ODC) & Over Weight Consignment (OWC) Studies & CAPEX Estimation (+/- 20% accuracy).

V. Validation & finalisation of in house adequacy study for capacity augmentation of Vadinar-Bina crude transfer facilities & Pipeline to about 12 MMTPA.

VI. To carry out EIA / RRA studies for the final configuration including crude pipeline, Refinery units revamp & petrochemical facility and arrange for getting Environment Clearance (EC) from statutory bodies.

4. PROJECT LOCATION & DETAILS

The new Cracker unit, its associated facilities , downstream polymer units , associated Utility and Offsite facilities and expansion envisaged in the existing Refinery shall be located in the available Refinery land.

Project location and details	
State/Country	Madhya Pradesh / India
Nearest Railway Station	Bina
Nearest Village	Agasod
Nearest City/Town	Bina
Nearest Airport	Bhopal - 178 km

Power Source

Power required for the new Petrochemical complex as well due to expansion in existing Refinery is to be sourced from Grid.

Water source

Raw water required for the new complex as well as refinery expansion is to be sourced from the Betwa river, as is presently done for the existing Refinery.

Construction Power and water source

To be sourced from the existing Refinery.

5. PROJECT CONFIGURATION

a. The process new units with capacities are described in Table 1.

Table 1: Process Unit Capacities		
Sl.No.	**Process Units (Refinery)**	**Capacity KTPA**
1	CRUDE UNIT/ VACUUM UNIT	6000*
2	BITUMEN BLOWING UNIT	300
3	FULL CONVERSION HYDROCRACKER UNIT (FCHCU)	40% capacity revamp and conversion of FCHCU to Once through HCU
4	FUEL GAS TREATING UNIT	80

5	SWS/ARU	SWS: 140 TPH ARU: 125 TPH
Sl.No.	**Process Units (Petrochemical)**	**Capacity KTPA**
1	ETHYLENE CRACKER UNIT	1200
2	LLDPE / HDPE UNIT	650
3	HDPE UNIT	500
4	POLY PROPYLENE UNIT (PP)	650
5	BUTENE-1 UNIT	50

** Overall crude processing post expansion will be 12,000 KTPA.*

b. COT and crude oil Pipeline:

- Vadinar Bina Pipeline capacity enhancement shall be evaluated for capacity up to 12 MMTPA
- New pipeline shall not be considered. However, addition of new intermediate pumping stations, modifications at existing pumping stations and looping lines, if required, shall be considered. Location of new pumping stations at existing pigging stations is preferred.
- Additional tanks and associated facilities, if required, at COT shall be considered.

c. Crude mix to be considered for COT and pipeline:

Based on Configuration Study Parcel size of crude mix to be considered for COT: Arab Mix: VLCC, 250 TMT. Saharan/Upper Zakum/KSL: Suezmax, 130 TMT

d. Product evacuation:

Refinery products evacuation shall be as per existing philosophy. For new products including polymers both road and rail modes shall be considered.

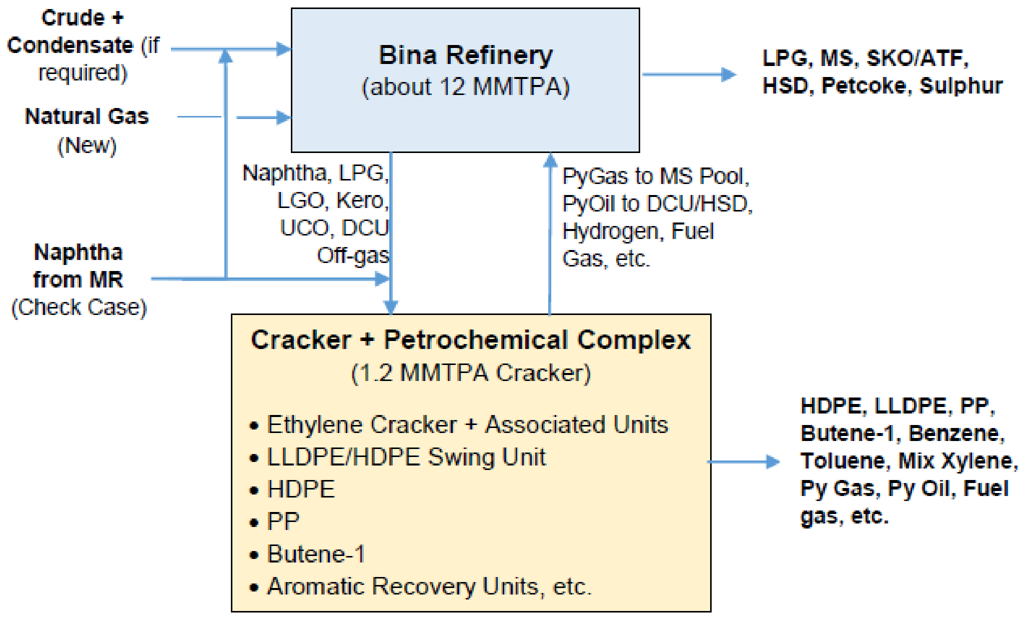
e. Project schedule:

Project schedule shall be considered as 48 Months (commissioning) from the date of award of PMC/EPCM consultant and licensor for Ethylene Cracker (Mechanical Completion in 45 Months).

f. Project cost:

The project cost shall be approximately Rs 35000 Cr.

6. BLOCK FLOW DIAGRAM



7. UTILITY SYSTEM CAPACITIES

The following additional utility streams shall be required to cater to the petrochemical block , polymer units as well as for the refinery expansion. This is over and above that required for the existing Bina Refinery.

- **Net power import from grid: 270 MW.**
- **Net water import : 4500 m3/hr**

Above are the only two utility stream required over the fence. Balance of the utilities like, cooling water, Nitrogen, Compressed air, Steam, Condensate, DM, treated raw water, fuel etc. shall be generated captive.

8. ENVIRONMENTAL CONSIDERATIONS

For environmental considerations, adequate care will be taken during conceptualization of the project and in process design to minimize the quantity of waste produced. In addition, solid, liquid and gaseous wastes generated from various processes in the complex will be handled in a manner that minimizes their impact on the environment. Some of the measures to be taken are as follows:

Solid Waste - It is recommended to dispose off solid waste such as spent catalyst, tank bottom sludge and ETP sludge in secured landfills outside the complex.

Liquid waste - A fully fledged Effluent Treatment Plant (ETP) shall be considered for the petrochemical complex to treat various liquid effluents generated in the refinery complex.

Gaseous Effluents - Atmospheric emissions related to the proposed facilities emanate mainly from the stacks located in various process units and in the Boiler house.
- ***SOx*** Control – The incremental SOx emissions from the Petrochemical complex and due to refinery expansion shall be **12 TPD** max.
- ***NOx*** Control - Low NOx burners shall be recommended to reduce NOx emission from all furnaces.

9. PROCESS DESCRIPTION

A brief process description for each of the new process units envisaged as part of expansion is provided below.

9.1 Cracker Unit

The expansion considers integration of the existing refinery complex with a cracker unit with Straight run Naphtha , paraffinic LPG, Gasoil, Kero, UCO and DCU off gas as feed. The duel feed cracker will produce polymer grade ethylene and polymer grade propylene, raw C4 mix, raw pyrolysis gasoline and Pyrolysis fuel oil. Associated units like PSA unit, Pyrolysis Hydrogenation Unit, Benzene Extraction Unit will be included in the Cracker Block.
The Gas/ Naphtha cracker plant basically consists of two sections:

- Furnace Section
- Separation Section

Furnace Section:
The heart of a Cracker plant is the cracking furnace system design and each Licensor of a Cracker unit have individually optimised the furnace design. The main objectives in cracking furnace design are:

- Increase in Ethylene selectivity
- Increase in Thermal efficiency
- Reduction in fuel gas burners

Separation Section:
The Cracker technology suppliers are concentrating on simplifying the separation section scheme to reduce the energy consumption in the plant and to reduce the capital investment. The separation train consists of quench, compression, recovery and refrigeration systems.

The quench oil section controls the gasoline end point, fuel oil flash point and maximises heat recovery while in quench water system, cracked gas, water and tar are separated. The light and heavy products are separated and light products are compressed. After compression, caustic scrubbing and drying, the light effluents enter the cold section of the unit which performs the separation of

a) Hydrogen
b) Polymer grade ethylene
c) Polymer grade propylene
d) C4 mix stream
e) Pyrolysis gasoline which is rich in aromatic hydrocarbons.

The following products shall also be separated out in the downstream Associated Units

a) Benzene
b) Hydrogenated Pyrolysis Gasoline
c) C9+
d) CBFS

9.2 LLDPE/HDPE Swing Unit

Catalyst preparation

High activity Ziegler catalyst is used for the production of narrow molecular weight distribution products. This catalyst is supplied ready-to-use by BP.

Polymerisation

The reactor is designed to ensure good mixing and a uniform temperature within the fluidized bed. Polymer particles grow within the fluidised bed over a residence time of several hours. Operating conditions within the reactor are mild. The reactor is made from carbon steel and has three main sections:

- A bottom section with a gas distributor to ensure homogeneous fluidisation.
- A cylindrical section containing the fluidised bed and equipped with catalyst injection and polymer withdrawal facilities.
- A conical bulb top section where gas velocity reduces, returning entrained polymer powder particles to the fluidised bed.

The gas leaving the reactor contains unreacted monomer, co monomers, hydrogen and inerts (primarily nitrogen and ethane). Conversion of monomers per pass is proximately 3%. Any fine particles leaving the reactor with the exit gas are collected by cyclones and recycled to the reactor. This greatly reduces fouling in the reactor loop and also prevents product contamination caused by particles formed in the loop, which may have different properties to the target grade. This is one of the reasons why the Innovene process makes such consistently high quality, gel-free products.

The gas then enters the first heat exchanger where the heat of polymerisation is removed before passing to the Enhanced High Productivity Separator. This specially designed vessel separates the condensed liquid, typically up to 15% by weight of the stream, from the loop gas, which is fed to the main fluidisation gas compressor. This provides the volumetric flow necessary to achieve the required fluidisation velocity in the reactor. The separated liquid is then pumped into the reactor via proprietary liquid injection nozzles into the heat of the fluidised bed.

In the reactor, pressure and gas composition are controlled continuously by varying the flow of feedstock into the reaction loop. The relative proportions of the feedstock are adjusted to meet the specification of the required polymer product. This is achieved using on-line analysers for hydrogen, ethylene and co monomers. A purge is provided to prevent accumulation of inerts.

Polymer Withdrawal and Degassing

The polymer powder is withdrawn from the reactor by simple, robust proprietary lateral discharge system and passed on to the primary degasser, where a part of the gas is flashed off, filtered and recycled to the main loop via the recycle compressor. The polymer powder is transferred to the secondary degasser, where most part of the residual hydrocarbon is removed and separated in the cryogenic Vent Recovery Unit. The degassed powder collected in the secondary degasser passes to a purge column, where trace hydrocarbons are removed and any residual catalyst activity is killed.

Powder is then transferred to the extruder via an intermediate surge bin, mounted directly above the extruder, which allows for routine extruder maintenance.

Grade Changes

On-line DCS transition control ensures consistently rapid and reliable grade changes. Changes of grade are made quickly and easily, with the minimum loss of throughput and the minimum generation of wide-specification product.

Finishing: Product Blending and Extrusion (Pelletising)

Polyethylene powder is transferred pneumatically to the product powder silo. Powder master batch incorporating additives is prepared in mixers or may alternatively be supplied in flexible intermediate bulk containers. The additives are commercially available but the formulations, which are part of Innovene technology, will be disclosed when a licence agreement has been signed. Virgin powder and additives are weigh-fed into the extruder. Pellets are extruded under water and are then dried before being conveyed by air to storage. The pellets conveyed from the pelletising section are homogenised in static homogenisation silos. After homogenisation, the pellets are transferred to storage silos.

9.3 HDPE Unit

Catalyst feeding

PZ Catalyst which is Ti catalyst is used to produce all HDPE grades. AT-Catalyst, which is tri-ethylaluminum, is used as a cocatalyst.

PZ-Catalyst preparation

PZ-catalyst is charged into PZ feed drum, which has been filled with a specified quantity of hexane, measured by flowmeter. PZ feed drum are kept agitated by means of PZ feed drum agitator respectively. Prior to charging of PZ-catalyst, the flexible connection tube to connect the PZ container to PZ feed drum, which is dried, shall be purged with nitrogen after it is connected.

AT- catalyst preparation

AT-catalyst is transferred by means of nitrogen pressure from AT container to AT feed drum after a specified quantity of hexane measured by flowmeter has been charged into AT feed drum. AT-catalyst solution is thus diluted to a required concentration. Meanwhile, vent gas in AT-catalyst system is discharged into flare system. PZ-catalyst which has been diluted to a specified concentration in PZ feed drum is fed to each polymerizer by means of PZ feed pump. AT-catalyst which has been diluted to a specified concentration in AT feed drum is fed to each polymerizer through AT feed sub drum by AT feed pump.

Polymerization

For the polymerization reaction, a low pressure hexane slurry process is employed, using Polymerizers lined up in parallel or series. Ethylene monomer, which is the main raw material, dehydrated hexane for adjusting the slurry concentration and catalyst are continuously fed at specified feed rates to the polymerizers. Hydrogen as molecular weight controller and either propylene or butene-1 for adjusting the density are continuously premixed with ethylene gas, and such mixture is fed into the recycle gas line leading to the polymerizers. The heat of reaction is removed by latent heat of hexane, slurry cooling system and cooling by the jacket on the polymerizers. Control of polymer properties, melt flow rate (MFR), density (D) and molecular weight distribution (NNI) of polymer, in the polymerizers is carried out by adjusting polymerization conditions.

Polymerizer recycle gas

Ethylene, hydrogen, and either propylene or butene-1 are mixed with polymerizer recycle gas, and fed to 1st Polymerizer / 2nd Polymerizer through the gas injection pipes. The fed raw material gases are thoroughly dispersed by the 3-stage turbine agitator to be dissolved in hexane, and the ethylene gas is polymerized in the presence of catalyst and forms polymer slurry having a specified concentration. At this time, the polymerization pressure is maintained by hydrogen partial pressure. Recycle gas comprising ethylene and hydrogen is blown into the bottom of the polymerizer and ethylene is polymerized during its passage through the adequately agitated hexane phase. More than a half of the heat generated by polymerization is removed by the latent heat of hexane. The recycle gas containing plenty of hexane vapor is transferred to 1st Overhead Condenser (2nd Overhead Condenser), condensed and cooled, and further transferred to 1st hexane Accumulator (2nd Hexane Accumulator) to be separated into condensate hexane and recycle gas. The recycle gas so separated is pressured in 1st Recycle Gas Blower (2nd Recycle Gas Blower) and blown into the bottom of the polymerizer while its flow rate is controlled so as to maintain the polymerization temperature at a specified value. Condensate hexane separated in 1st hexane accumulator is recycled to the polymerizer through 1st Condensate Recycle Pump (2nd condensate Recycle Pump). Part of the condensate hexane is used for flushing at a specified rate in the gas outlet piping for 1st polymerizer (2nd polymerizer).

Slurry cooling

Polyethylene slurry in polymerizer is circulated through slurry cooler by Slurry Cooler Pump to remove polymerization heat together with recycle gas system and reactor jacket cooling system.

Separation and drying section

Separation

The product slurry is continuously fed through 2nd slurry transfer pump to horizontal-type centrifuge revolving at a high rotating speed, in which polymer is separated by centrifugal force. The product slurry fed to the rotating bowl of centrifuge is pressed to the inside wall of rotating bowl under centrifugal force and separated into product and hexane solvent. The polymer is discharged from the centrifuge by the screw conveyor provided in the bowl in the form of wet cake containing hexane and fed to dryer via wet cake screw feeder. Meanwhile, hexane overflows the weir provided in the bowl and flows into mother liquor drum and then pressured by mother liquor transfer pump so that part of it will be sent back to polymerization section and the remainder will be fed to hexane recovery section. The piping to transfer hexane separated in centrifuge is provided with jacket or steam tracing to prevent the low polymer dissolved in the hexane from solidifying.

Drying

Steam tube rotary dryer

Mixed gas consisting of nitrogen and hexane vapor flows through Dryer counter currently with the product. When the product power leaves the dryer, it contains less than 0.2% volatile matter (as hexane) and its temperature is approx. 100°C. Low pressure steam is supplied to the steam tube in dryer as the heat source after its pressure and temperature have been reduced by means of steam cooler.

Dryer gas circulation system

The mixer recycle gas from dryer containing a small amount of fine polymer particles goes into Dryer Gas Scrubber. The circulation liquid in dryer gas scrubbing pumps collects the polymer entrained with the mixed gas. The collected polymer is recovered through dryer gas scrubbing pump into 2nd flash drum, while the liquid level of dryer gas scrubber is controlled by level controller.

The mixed recycle gas cooled in dryer gas condenser is pressured by dryer gas blower and is cooled by dryer gas cooler with brine to decrease hexane content in it. The recycle gas from dryer gas cooler is heated by dryer gas heater with low pressure steam. The non-condensable gas which leaves the outlet of purge gas condenser is pressured by off gas compressor and part of it is supplied to the gland of dryer for flushing and the surplus is discharged to the flare system.

Pelletizing, storage and packing section

Powder hopper

The product powder from rotary steam tube dryer is transferred to the nitrogen gas pneumatic powder conveying system through powder rotary valve. The product that is forwarded by powder transfer blower is continuously separated by powder cyclone and dropped into powder hopper. Nitrogen gas separated in powder cyclone is filtered through bag filter to be re-circulated. The very fine powder entrained with nitrogen gas in bag filter is continuously recovered through powder rotary valve into powder hopper.

Pelletizing system

Polyethylene powder, solid stabilizers, liquid stabilizer and w-stabilizer are fed to homogenizer then to pelletizer having a twin-screw type continuous mixer with gear pump where they are mixed and kneaded. Molten polymer is pushed towards the die by gear pump system. Then the molten polymer is extruded through the die-hole into the cutter bowl through which pellet cooling water is circulated. The extrudate is cut into pellets by the revolving cutter. The resin in the pellet form is transferred to pellet separator with circulated PCW (pellet cooling water). For protection of pellet dryer, a grid is provided PCW Strainer to remove any fused blocks of pellets. The pellets, which passed the grid, are sent to pellet dryer after they are drained on the perforated plate screen. The pellet cooling water separated by PCW strainer and pellet dryer flows into PCW Drum, from which it is re-circulated to the cutter box of pelletizer after pressured by PCW Circulation

Pump and cooled by PCW Cooler. Powdery matter suspended in the pellet cooling water is discharged out of the system through the overflow outlet of PCW drum by continuously feeding process water (PW) to PCW drum through the FG. Since this wastewater contains solid particles and stabilizers suspended or dissolved in it, it is transferred to Powder Separator, where solids are separated so that water itself can be disposed of as “oily water”. Product pellets are classified by pellet Vibrating Screen into oversize, normal, and undersized products. Normal size pellets which flow in Pellet Separator Hopper are pneumatically conveyed to the specified silo through Pellet Rotary Valve by pellet.

Pellet blending & transfer system

Pellet Silos each of which has a capacity of 160 ton has been considered. In order to rectify such fluctuations of quality due to possible variance in the operating conditions at process control, the pellet blending is carried out through transferring the pellet to Packer Hopper. Product pellets are pneumatically conveyed blending to Packer Hopper by Pellet Blending & Transfer Blower of which conveying capacity is 30 ton/hr (max).

Packing

Pellet transfer capacity from product silos to packing facilities (or shipping facilities) is decided under following assumptions.
1. Product pellets are packed into sacks before shipping.
2. Packing capacity
3. Packing operation

9.4 POLY PROPYLENE (PP) Unit

Fresh propylene from OSBL is fed through propylene dryer to the reactor along with the required catalyst, co-catalyst, hydrogen and stereo-modifier. For production of two special grades with small ethylene content, ethylene vapor is also fed to the reactor. The polymerization reactors each have a nominal volume of 75 m3 with identical stirrer and drive systems. Polymerization itself is carried out in a gas phase stirred reaction. Heat removal is managed by evaporative cooling. Liquid propylene entering the reactor vaporizes and thereby removes the exothermic reaction energy. Reaction gas is continuously removed from the top of the reactor and filtered. Reactor overhead vapor (“Recycle Gas”) is condensed and pumped back to the reactor as coolant. Non-condensable gases (mainly H_2 and N_2) in the recycle gas are compressed and also returned to the reactor.

The polypropylene product powder is blown out of the reactor under reactor operation pressure. The carrier gas and powder pass into the powder discharge vessel where powder and gas are separated. The carrier gas is routed through a cyclone and filter to remove residual powder, then scrubbed with white oil and sent to compression. Powder from the discharge vessel is routed via rotary feeders to the purge vessels which are operating in parallel. Nitrogen is used to purge the powder off residual monomers. The overhead gas from the purge vessels is sent to a common membrane unit for monomer/nitrogen recovery. As refrigerant for the membrane unit fresh Propylene is used. The recovered nitrogen is sent back to the purge vessels for further use. The condensed monomers from the purge gas are combined with the filtered carrier gas, and then sent to scrubbing and subsequently to carrier gas compression.

The PP powder from the purge vessels is pneumatically conveyed by a closed loop nitrogen system to the powder silos. The powder product from these silos is fed to the extruder where polymer powder and additives are mixed, melted, homogenized and extruded through a die plate, which is heated by hot oil. The extruding section is electrically/steam heated.

Pelletizing of the final product is carried out in an underwater pelletizer where the extruded polymers - after passing the die plate - are cut by a set of rotating knives. The polymer/ water slurry is transported to a centrifugal dryer where polymer and water are separated. Water is recycled to a pellet water tank, for which demineralized water is used as make-up. The cooled pellets (~60°C) are pneumatically conveyed to the pellet blending silos by an air conveying system. After homogenization in the blending silos the pellets are conveyed to the bagging and palletizing system.

9.5 BUTENE-1 Unit

The dimerization reaction is activated by the mixing of two specific catalysts. The first one, named T.E.A, is an alkyl-aluminium compound, the second one, named LC 2253 (AXENS proprietary catalyst) is made of a titanium compound and a promotor. Both catalysts are separately stored in diluted T.E.A. day drum and LC 2253 storage drum, filtered and then pumped by metering pumps to the Reactor. The diluted alkyl-aluminium catalyst (T.E.A) and the diluted LC 2253 catalyst are fed to the reactor 32-R-201 through the pump around loops. In case hexane is used (during start-up), it can be dried before using via Hexane Dryer, before being sent to Washing Hexane Drum. The regeneration of the dryer is carried out with hot nitrogen heated up in Nitrogen Heater. Effluents from regeneration are then sent to flare. Nitrogen Heater ensures also the drying of Pump around Loops after maintenance with hot nitrogen.

Reaction / Catalyst removal sections

The ethylene feedstock coming from Polymer Unit downstream of purification section or directly from cracker is mixed with the unconverted ethylene which is recycled from the recycle column reflux drum. The ethylene stream enters the reactor through a distributor, which improves the dispersion of the ethylene in the liquid. The reaction is exothermic: the heat of reaction is removed by the pump around coolers installed on recirculation lines around the reactor. The recirculation is maintained by pump around pumps. The liquid reactor effluent withdrawn from bottom of reactor must be vaporized to remove all the traces of catalysts. Part of the vaporization occurs in the vaporizers by steam condensation; the vapor and liquid phases are separated in the flash drum. The last step of vaporization is achieved through the thin film evaporator which is fed under flow-control reset by the level of the flash drum.

The residual liquid is collected in the evaporator receiver drum and feeds under level control the spent catalyst drums which are connected to the flare and steam traced to remove the remaining light compounds. The remaining liquid is either sent to isocontainers and then to incinerator or sent to Fuel Oil. The vapors from the thin film evaporator flow through the evaporator K.O. drum which traps any liquid carry-over. The vapors are then mixed to those got from the flash drum and to the vapor flow from the reactor top. The product, currently stripped from the catalysts, is condensed through the recycle column feed condenser and feeds the recycle column feed surge drum. To stabilize the product before vaporizing it, pure amine is injected to the reactant effluents filters. This prevents any detrimental isomerization of butene-1 into isobutene and butene-

2, which could be promoted by temperature downstream, during the vaporization step, without amine injection.

The amine, unloaded from drums by the amine unloading pump, is stored in the amine storage drum, and sent to the process by the amine pumps.

Distillation section

The liquid phase from recycle column feed surge drum is pumped to the recycle column. A partial condensation of its overhead vapors takes place in the recycle column condenser. Due to the presence of methane and ethane in the feedstock, a slight venting to Naphtha Cracker is necessary to prevent from any incondensable vapor accumulation. The vapor (mainly ethylene) is recycled back under pressure control to the reactor feed line.

The reboiling of the column is ensured in the recycle column reboiler under temperature control resetting the steam flow rate to the reboiler. The butene-1 column duty is to provide the specification in heavy components of butene- 1 product. The butene-1 product is withdrawn as liquid distillate from the column overhead by means of the butene-1 column reflux pumps under level control of the butene-1 column reflux drum. The C6+ cut is withdrawn, at the butene-1 column bottom. The C6+ cut is routed, after cooling through the C6+ product cooler, to the C6+ storage drum.

Product drums storage

The butene-1 leaving the distillation section can be routed to any of the storage drums "on-spec" drum or an “off-spec” drum after has been cooled down at 40 deg. C in the butene-1 cooler.

The butene-1 on-spec product is routed to OSBL storage tank after analysis, by means of the pump. The off-spec product is routed to C4 mix storage, but can also be recycled in the butene-1 column, if it’s content in C6 and heavier is too high. A part of this butene- 1 product is used for flushing pump around pumps, reactor effluent pumps, passivation pumps and ethylene distributor by means of flushing pumps. Another part of this Butene-1 is used as carrier or T.E.A. and LC 2253 catalysts to the reactor.

9.6 CDU/VDU

Crude /Vacuum Distillation Unit

Crude from offsite storage is received at CDU/VDU plant battery limit. The crude is subsequently heated in preheat exchangers by hot streams of CDU/VDU. Crude picks up heat in the preheat exchangers before being routed to Crude desalter. After desalter, crude picks up heat from hot streams of CDU/VDU and finally routed to crude heater. Heated and partially vaporised crude enters crude column through feed nozzle. The column has five side draws, namely, Light Naphtha (SN), Heavy Naphtha (HN), Kerosene (Kero), Light Gas Oil (LGO) and Heavy Gas Oil (HGO).

Vacuum Distillation Unit

Hot RCO from Crude column bottom is pumped by RCO pumps to Vacuum heater. Each coil outlet of vacuum heater joins the transfer line and is routed to Vacuum distillation column. The mixed vapour & liquid stream from the heater is introduced to the Flash zone of Vacuum column. Heated & partially vaporised RCO from Vacuum Heater enters the Vacuum Column. An open ended tangential entry device and a large empty space above flash zone ensure optimal vapour liquid separation. Major product from VDU is Vacuum Diesel, LVGO, HVGO, slop and VR.

9.7 BITUMEN BLOWING UNIT

The Biturox unit is designed for production of the road bitumen grades VG-40, VG-30 and VG-10 based on continuous operation by oxidation of feed material – the Vacuum Residue (VR) and flux oil (Vacuum Slop, Vacuum Diesel and HHGO).

The BBU consists of the three main sections as follows:

- Feed Section - with the feed supply, feed blending and feed pre-heating
- Reactor and Product Section – with the Biturox reactor, process air and water supply, product pumps and product cooling
- Off Gas Treatment Section – with the Off Gas Knock Out Drum and Scrubber Section .

9.7 SOUR WATER STRIPPER (SWS) UNIT

Refinery Sour Water Stripper is designed to treat sour water from CDU/VDU. The H2S recovered is sent to SRU for reduction to elemental merchant-grade Sulphur. The Ammonia-rich stream is considered to be disposed off by burning in the SRU Ammonia Incinerator. The stripped water from Single Stage SWS is sent to CDU desalter make-up, and to ETP for disposal. Sour water from CDU/VDU units is received from a common line in a sour water surge drum floating on acid gas flare header back pressure. This surge drum is a three phase (V-L-L) separator. Flashed hydrocarbon vapors are separated and routed to acid gas flare. Oil carryover, if any, is skimmed off from drum and drained to OWS.

9.8 AMINE REGENERATOR (ARU) UNIT

The process objective of ARU is to regenerate the rich amine streams received from CDU/VDU and FGATU. After regeneration, the lean amine shall be re-circulated back to the units through lean amine distribution network. The H2S rich acid gas from amine regenerators shall be further processed in the downstream Sulfur Recovery Units (SRU) for recovery of sulfur.